Soil-Based Onsite Wastewater Treatment and the Challenges of Climate Change

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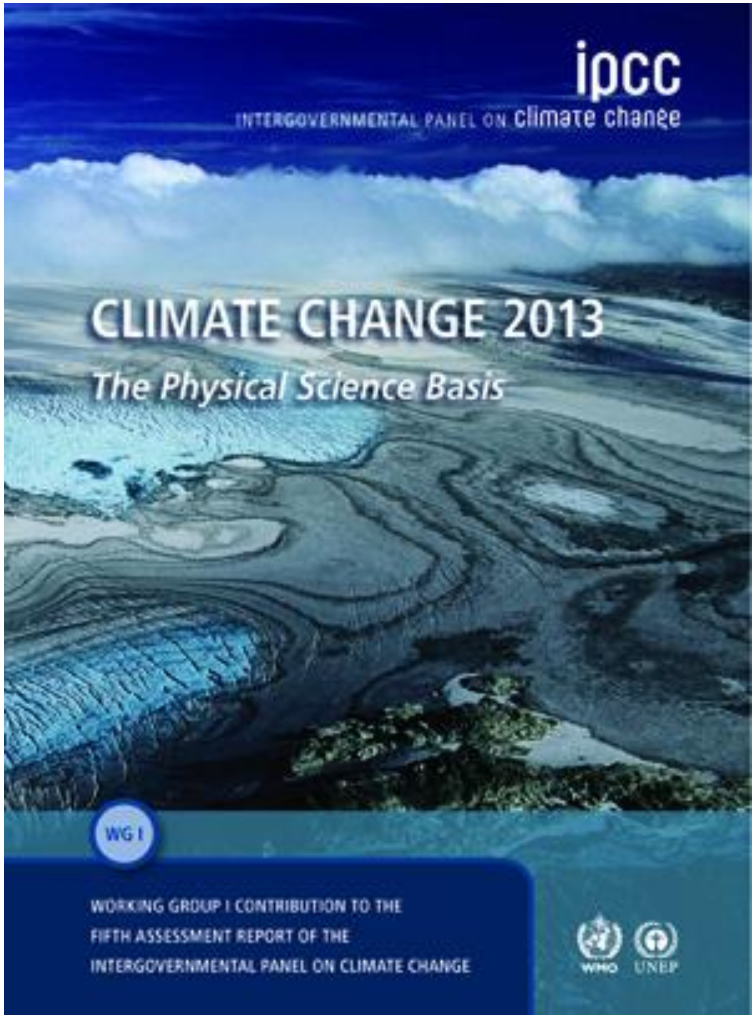
THE UNIVERSITY OF RHODE ISLAND
RHODE ISLAND SEA GRANT
USDA NIFA United States Department of Agriculture National Institute of Food and Agriculture

Overview

- Climate change
- Potential effects

- What do we do?



Climate Change

Sea level rise? Drier, wetter? Warmer?

ASIA PACIFIC

515 COMMENTS

Borrowed Time on Disappearing Land

Facing Rising Seas, Bangladesh Confronts the Consequences of Climate Change

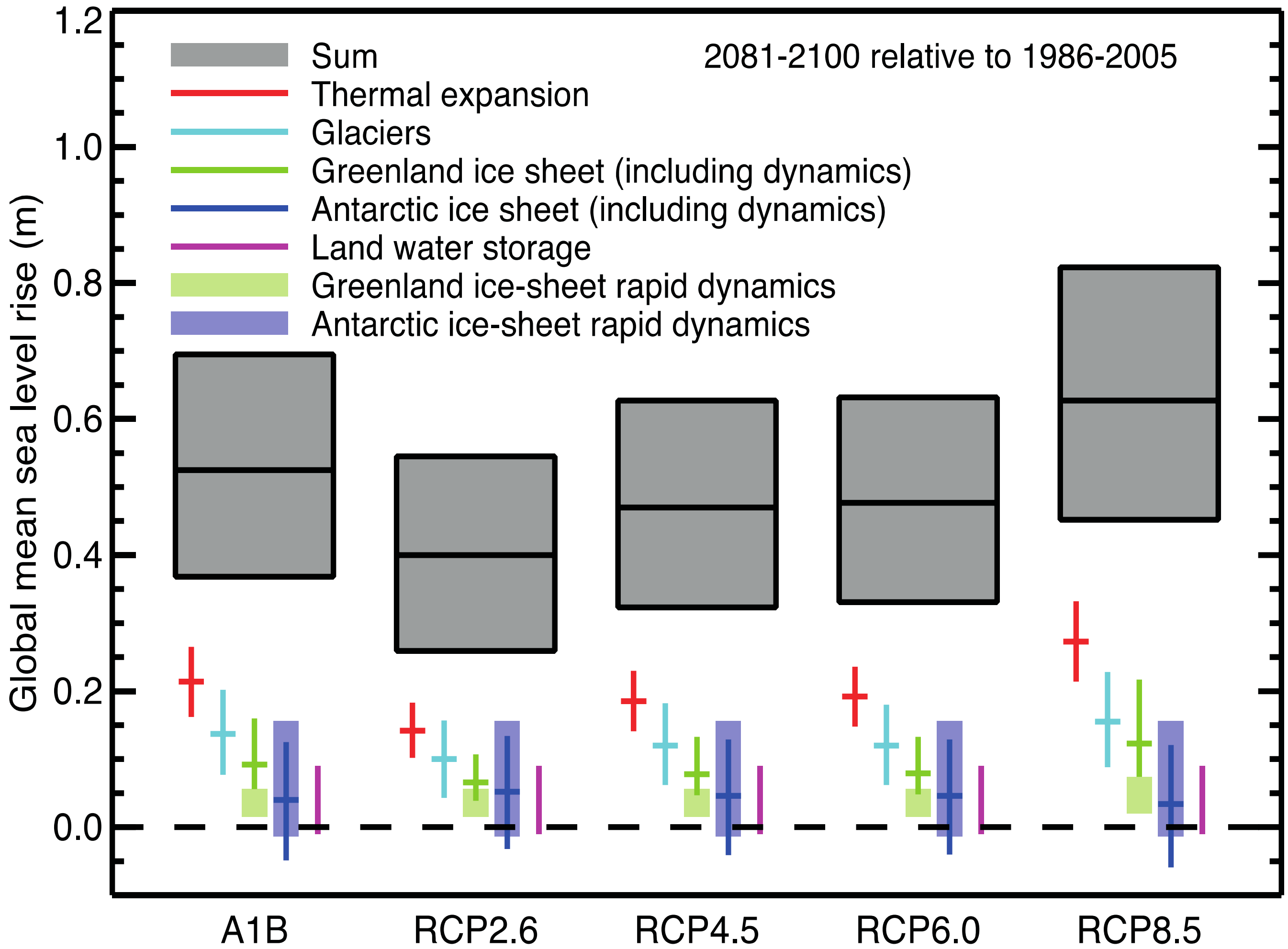
By GARDINER HARRIS MARCH 28, 2014

Bangladesh, with its low elevation and severe tropical storms, is among the countries most vulnerable to the effects of climate change, though it has contributed little to the emissions that are driving it. Kadir van Lohuizen for The New York Times

EMAIL
FACEBOOK

DAKOPE, Bangladesh — When a powerful storm destroyed her riverside home in 2009, Jahanara Khatun lost more than the modest roof over her head. In the aftermath, her husband died and she became so destitute that

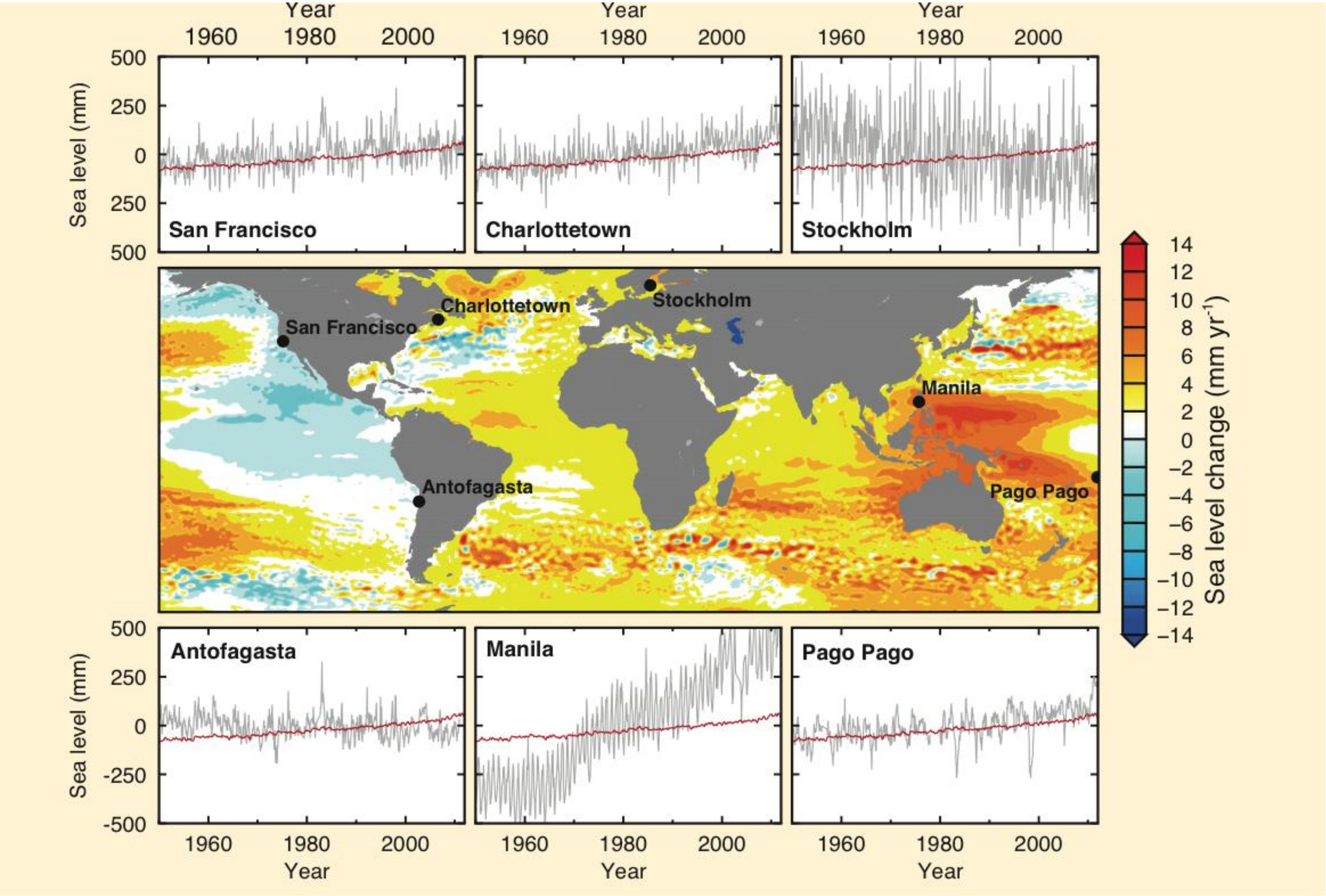
Sea Level Rise



IPCC (2013)

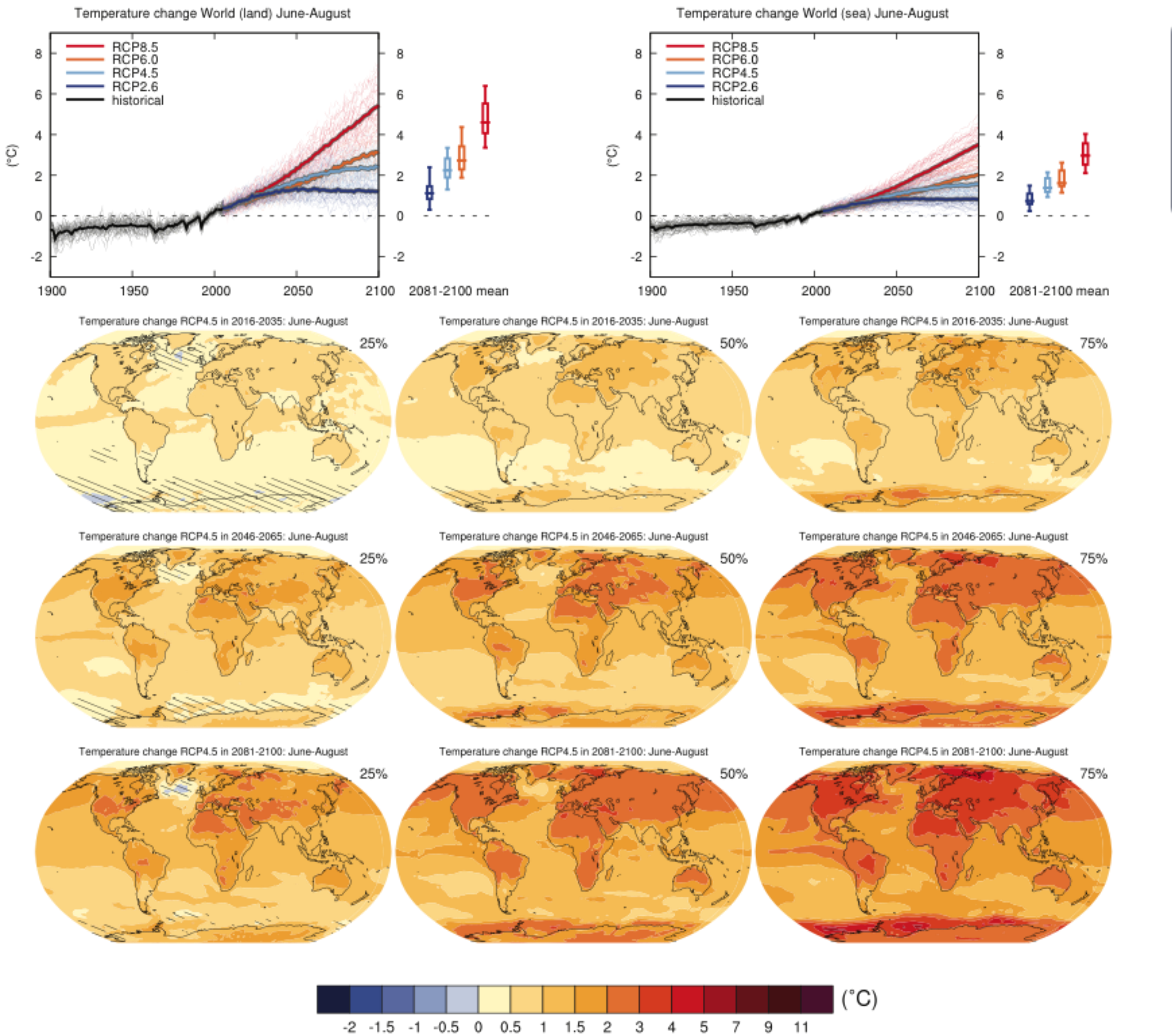
Sea level is rising

Sea Level Rise



IPCC (2013)

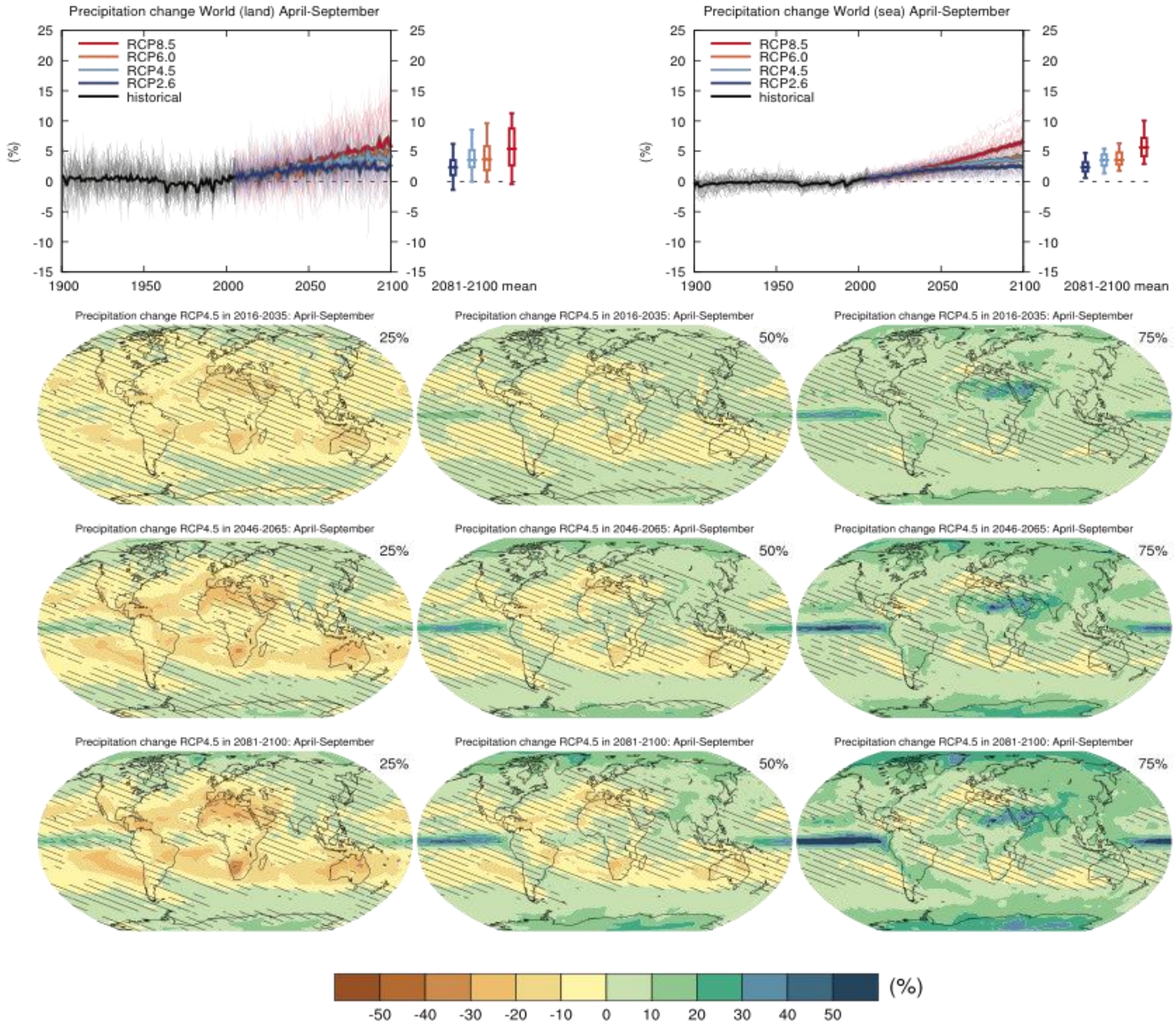
Temperature changes



IPCC (2013)

Temperature is going up

Precipitation changes



IPCC (2013)

Precipitation will change

HURRICANE SANDY
A Year Later

Deciding Whether It's Lights Out

Coming Back: A Year of Recovery

A Storm Still Felt

Turning Hurricane Sandy's Scars Into Badges of Survival

FACEBOOK | TWITTER | GOOGLE+ | EMAIL | SHARE

A Storm Still Felt

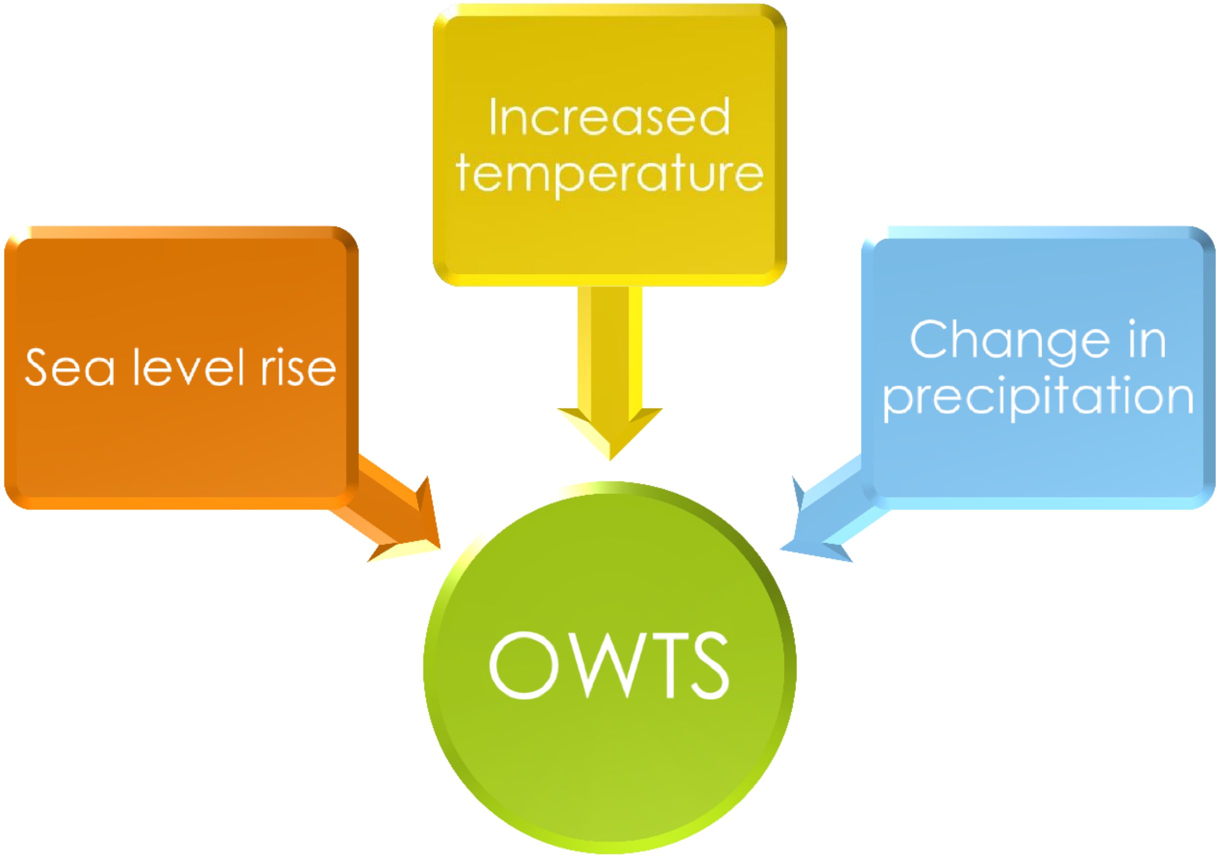
A November 2012 photograph shows the block where Aidan White, story below, and his family lived. Kirsten Luce for The New York Times

Extreme Events

Phenomenon & direction of trend	Early 21st century	Late 21st century
Warmer and/or fewer cold days and nights over most land areas	**Likely** (66 - 100%)	**Virtually certain** (99 - 100%)
Warmer and/or more frequent hot days and nights over most land areas	**Likely** (66 - 100%)	**Virtually certain** (99 - 100%)
Warm spells/heat waves. Frequency and/or duration increases over most land areas	**Not assessed**	**Very likely** (90 - 100%)
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	**Likely** (66 - 100%) over many land areas	**Very likely** (90 - 100%) over most of the mid-latitude land masses and over wet tropical regions
Increases in intensity and/or duration of drought	**Low confidence**	**Likely** (66-100%) on regional to global scale
Increased incidence and/or magnitude of extreme high sea level	**Likely** (66 -100%)	**Very likely** (90 - 100%)

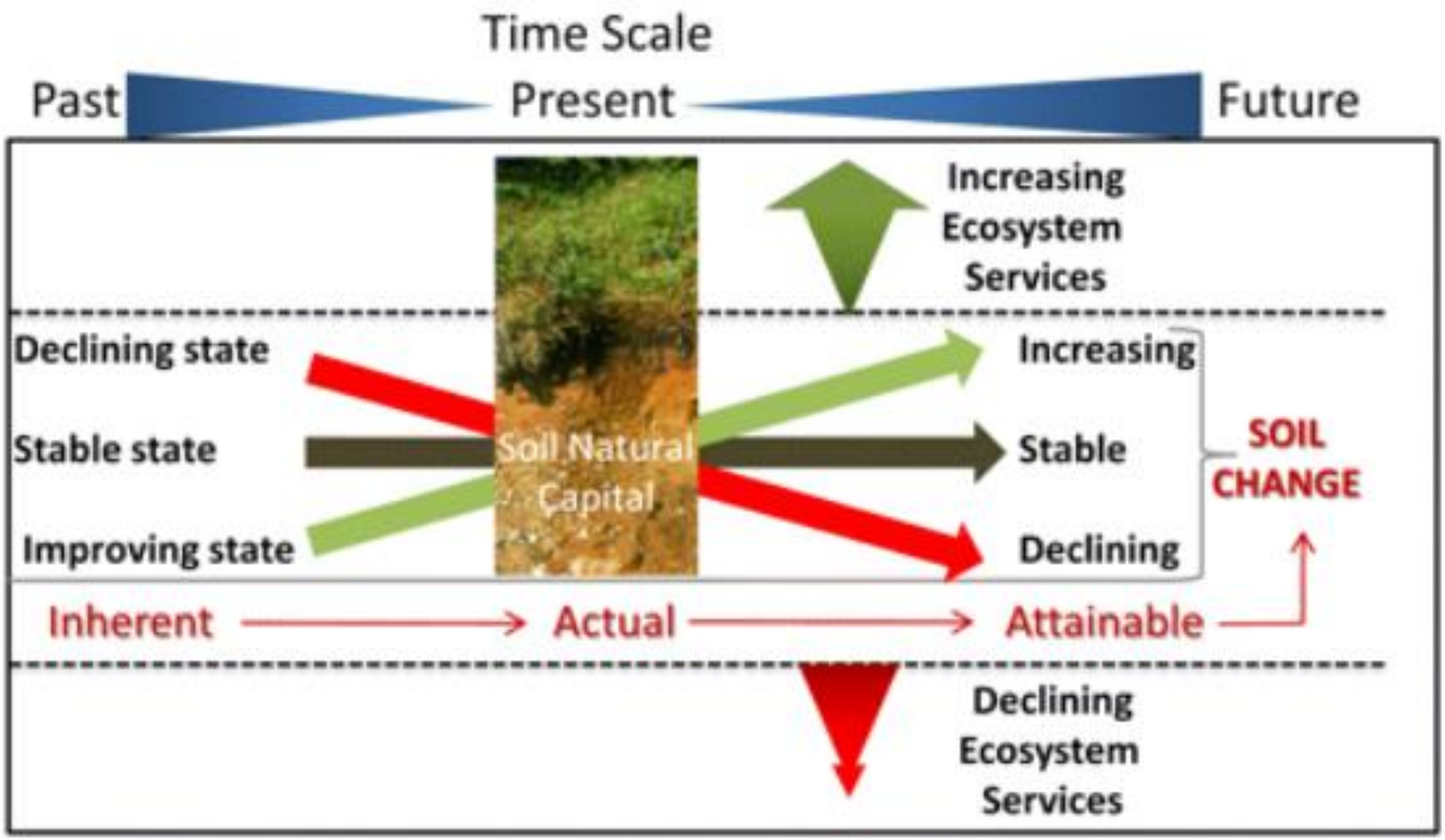
Adapted from IPCC (2013)

Potential Effects

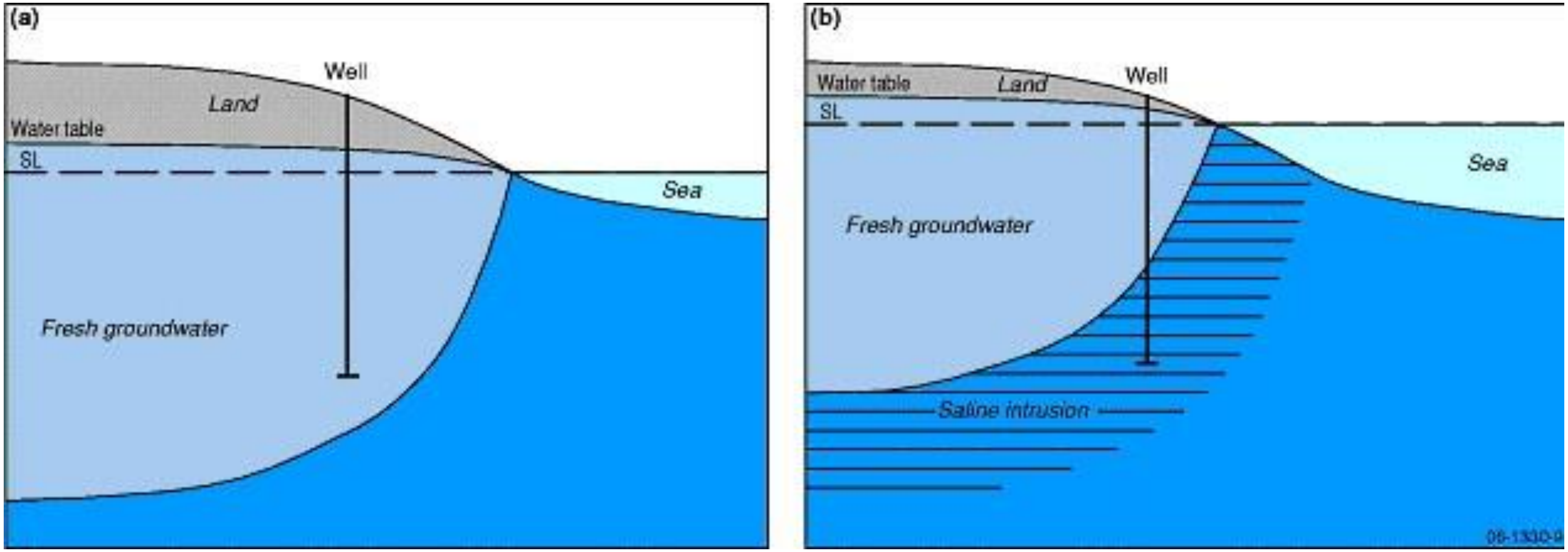

Increased temperature
Sea level rise
Change in precipitation
OWTS

Soil ecosystem services (values and functions) –

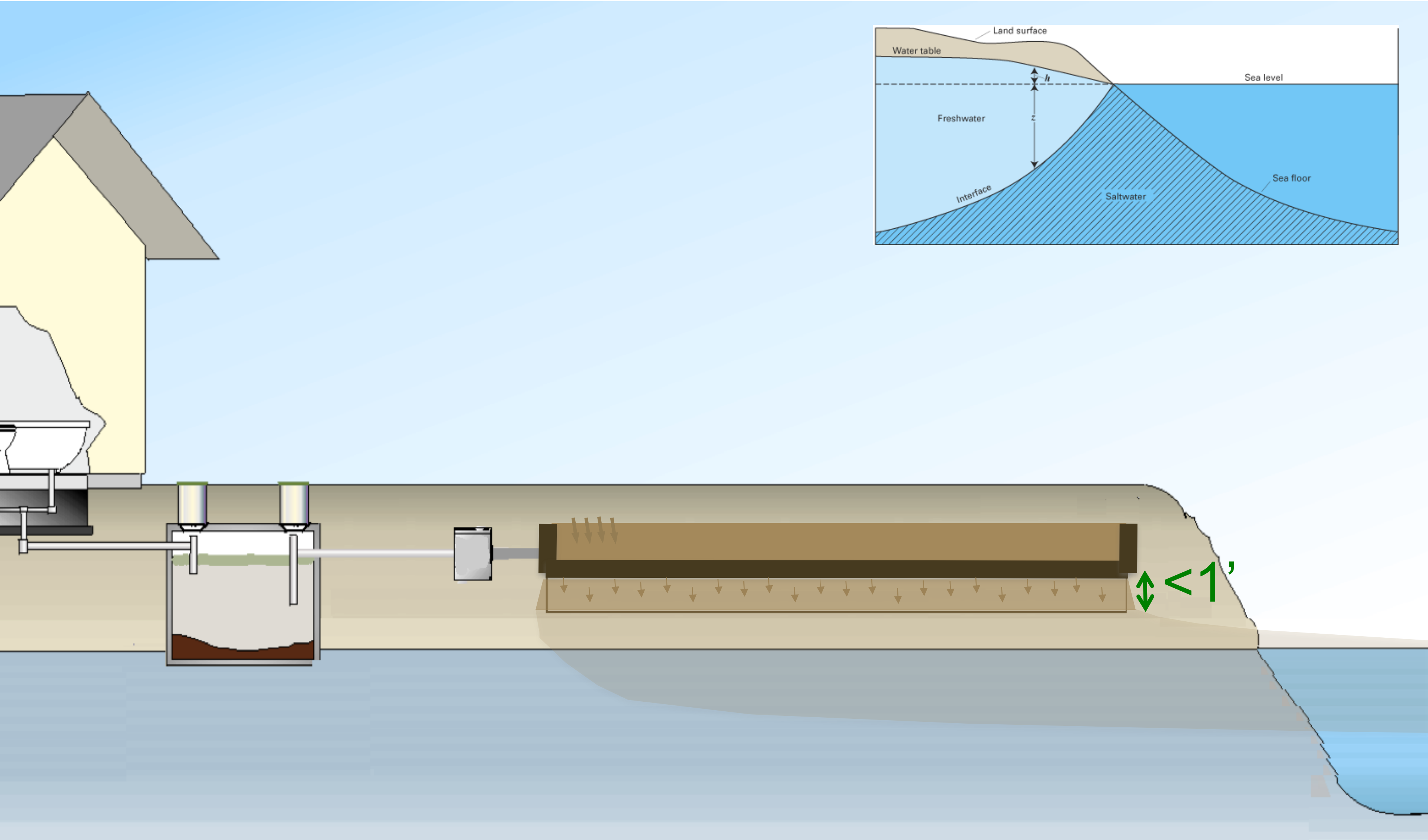
- Wastewater dispersal
- Infiltration and deep percolation
- Renovation / treatment



Sea Level Rise

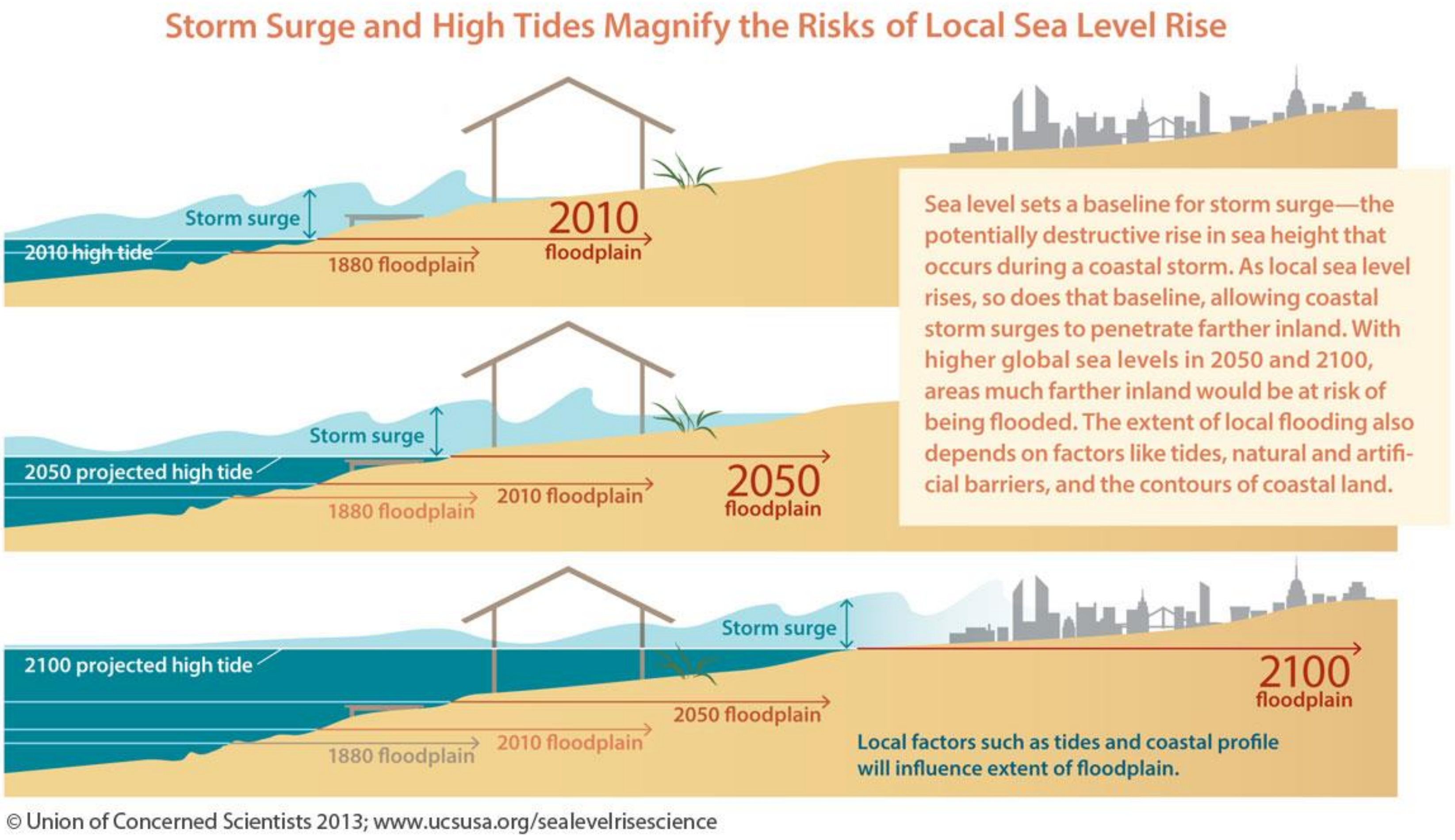


Chronic effects: Long-term sea level rise raises water table



Reduced OWTS function under elevated sea level / groundwater conditions

Acute effects

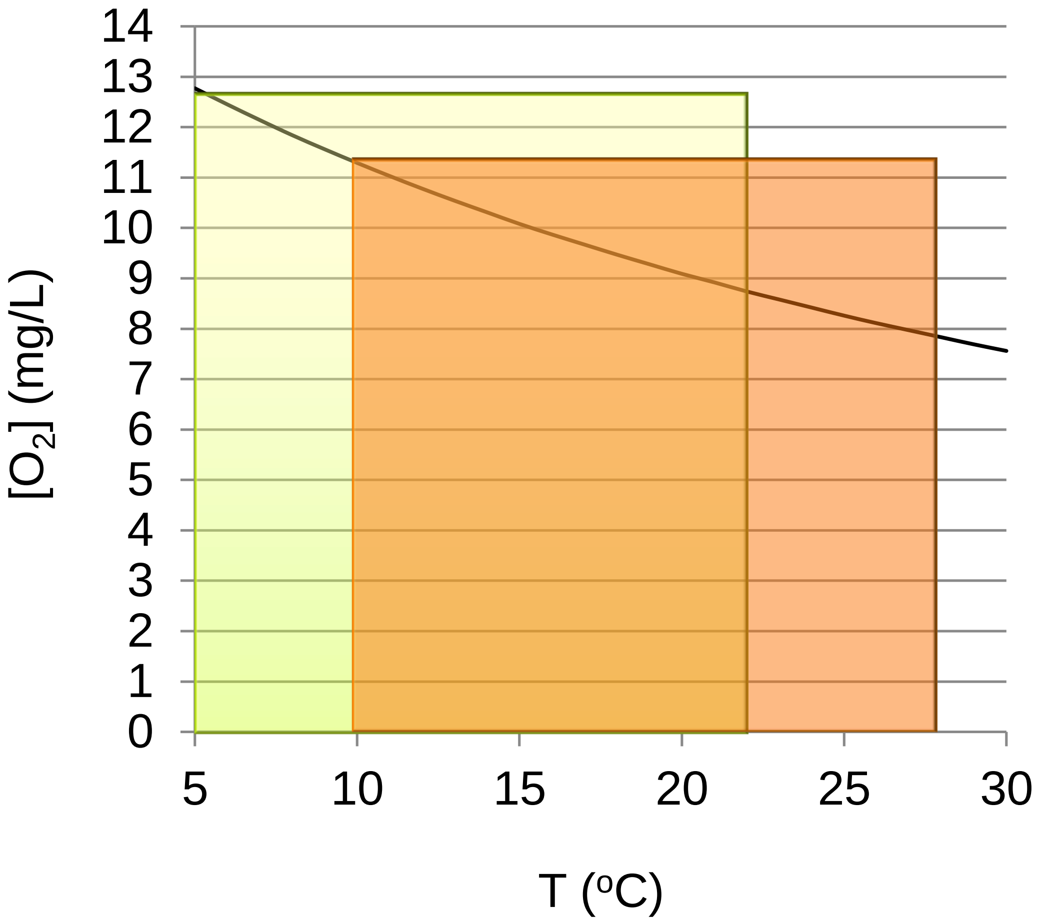


Acute effects

Whole system losses

Photo: D. Potts

Physical effects of rising temperature



Biological effects of rising temperature

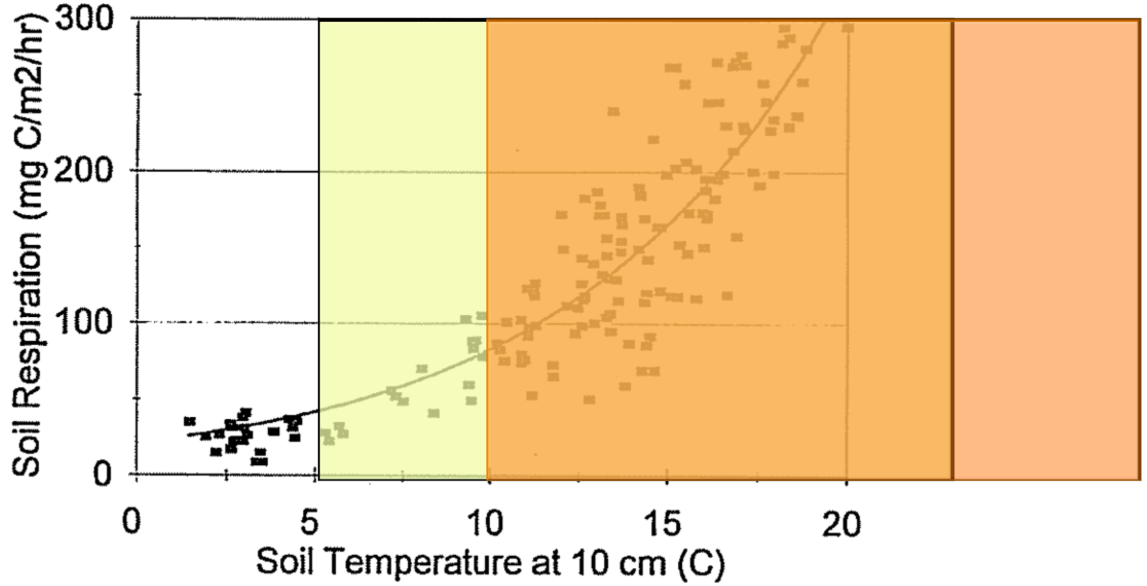


Fig. 4 Seasonal temperature dependence of soil respiration. Each square is a mean of six flux and temperature measurements made at one of the study areas at one date. The fitted function is:. Flux = $21.13 \times e^{(0.1371 \times \text{temp})}$. $R^2 = 0.80$, which is significant at $\alpha = 0.01$ (d.f. = 154).

Davidson et al. (1998)

Biological effects of moisture changes

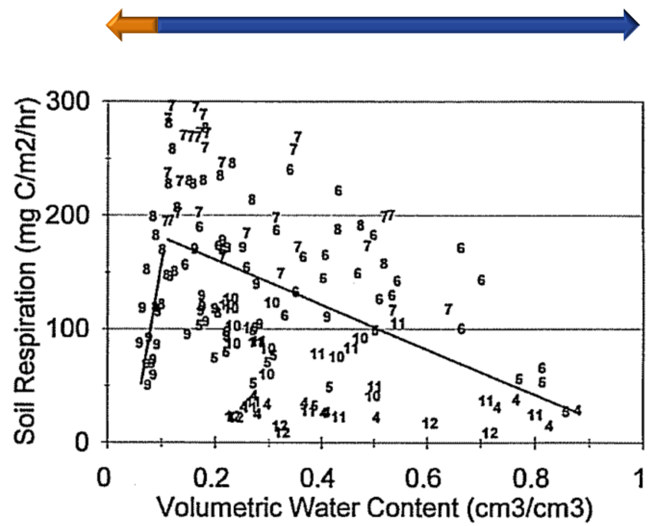


Fig. 7 Correlations of volumetric water content and soil respiration. The plotting symbol represents the month of the year that the measurements were made. Each datum is a mean of 3 or 4 TDR water content measurements and 6 flux measurements for a study area on a given date. The August (8) and September (9) data where water content was < 0.12 cm^3 cm^{-3} were fitted to the linear regression: flux $\alpha = -128 + (2852 \times \text{water content})$; $R^2 = 0.48$, which is significant at $\alpha = 0.05$ (d.f. = 21). The data from the rest of the year where water content was > 0.12 cm^3 cm^{-3} were fitted to the linear regression: flux = $201 - (198 \times \text{water content})$; $R^2 = 0.22$, which is significant at $\alpha = 0.01$ (d.f. = 131).

Davidson et al. (1998)

Biological effects of moisture changes

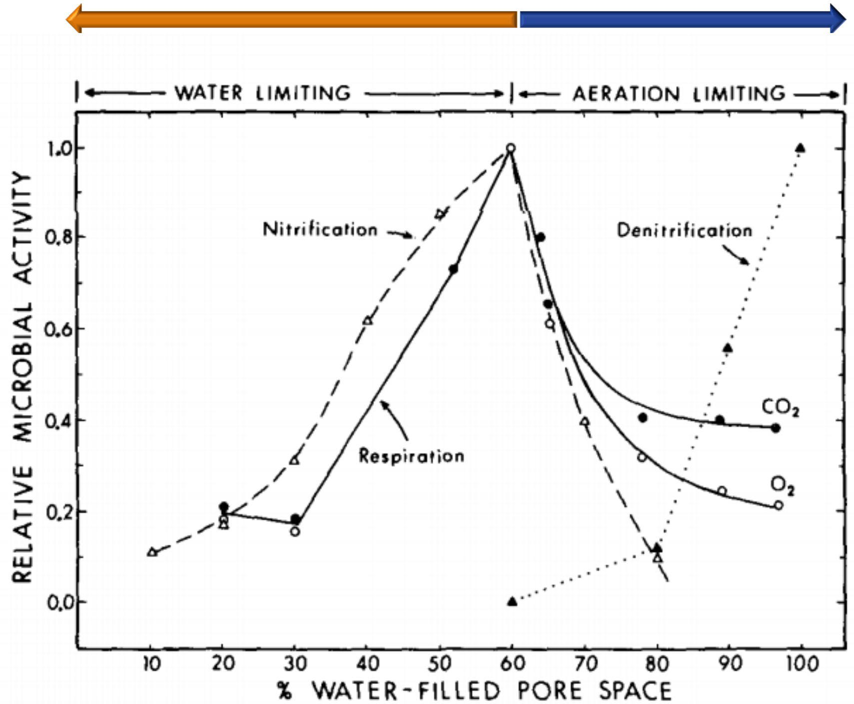


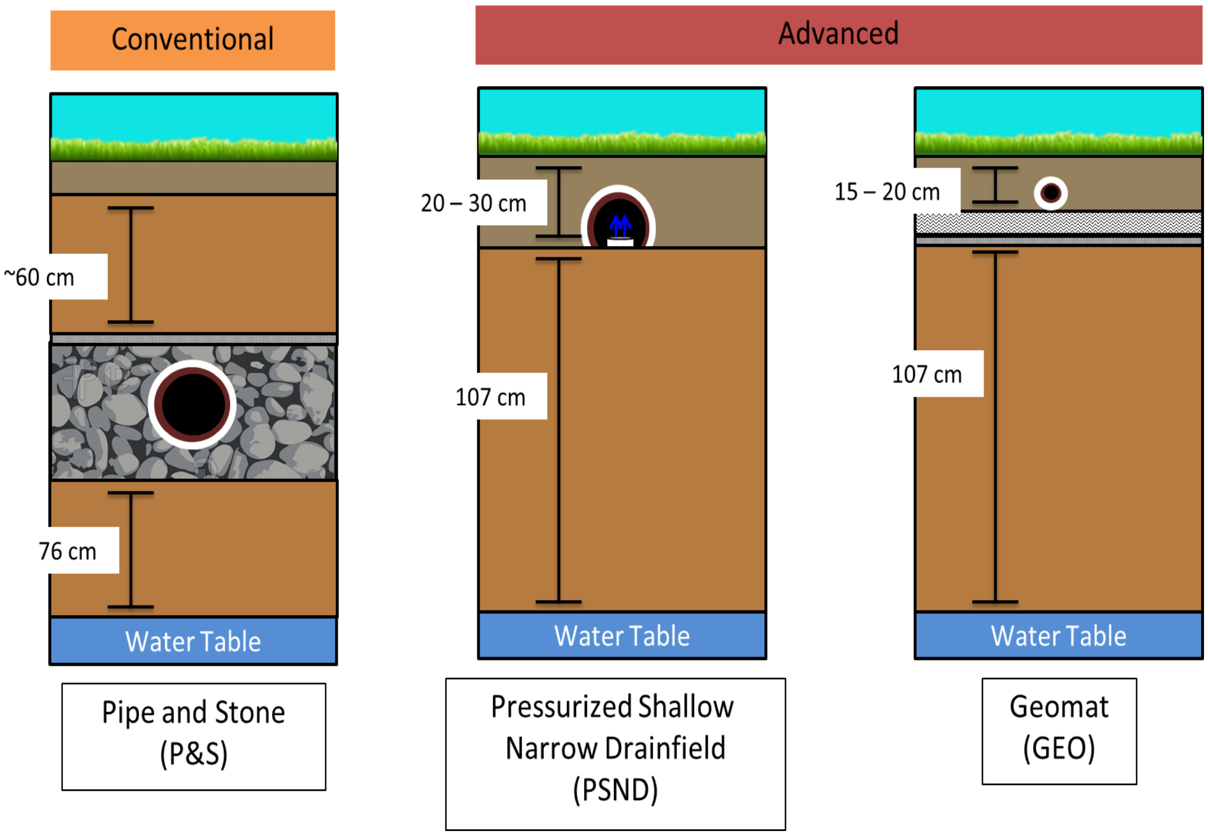
Fig. 1—The relationship between water-filled pore space and relative amount of microbial nitrification (after Greaves and Carter, 1920), denitrification (after Nommik, 1956), and respiration [O_2 uptake (○-○) and CO_2 production (●-●) as determined in this study]. Data for nitrification originally expressed as percentage water-holding capacity.

Linn and Doran (1984)

Hypothesized Effects of Climate Change

Property/Process		
Volume	↑	↓
Strength	↓	↑
Oxygen	↓	↓
Respiration	↑	↑
Nitrification	↓ (?)	↓ (?)
Denitrification	↑ (?)	↑ (?)
Xenobiotic degradation	↓	↓
S oxidation	↓	↓
P retention	↓	↓
Pathogen removal	↓	↑

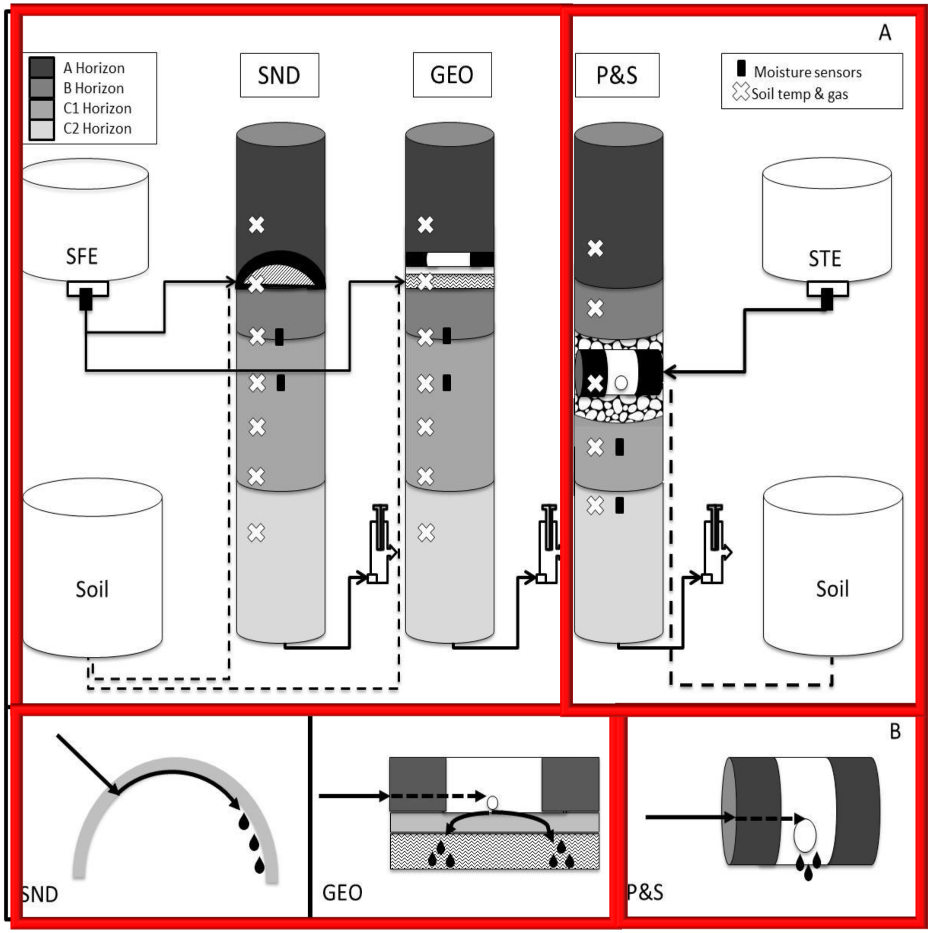
Testing the Hypothesized Effects of Climate Change



Research components

- Differences among conventional and advanced technologies
- Mechanisms of N removal
- Removal of estrogenic PPCPs
- Tested under current conditions and a climate change scenario

Testing the Hypotheses: Intact Soil Mesocosms



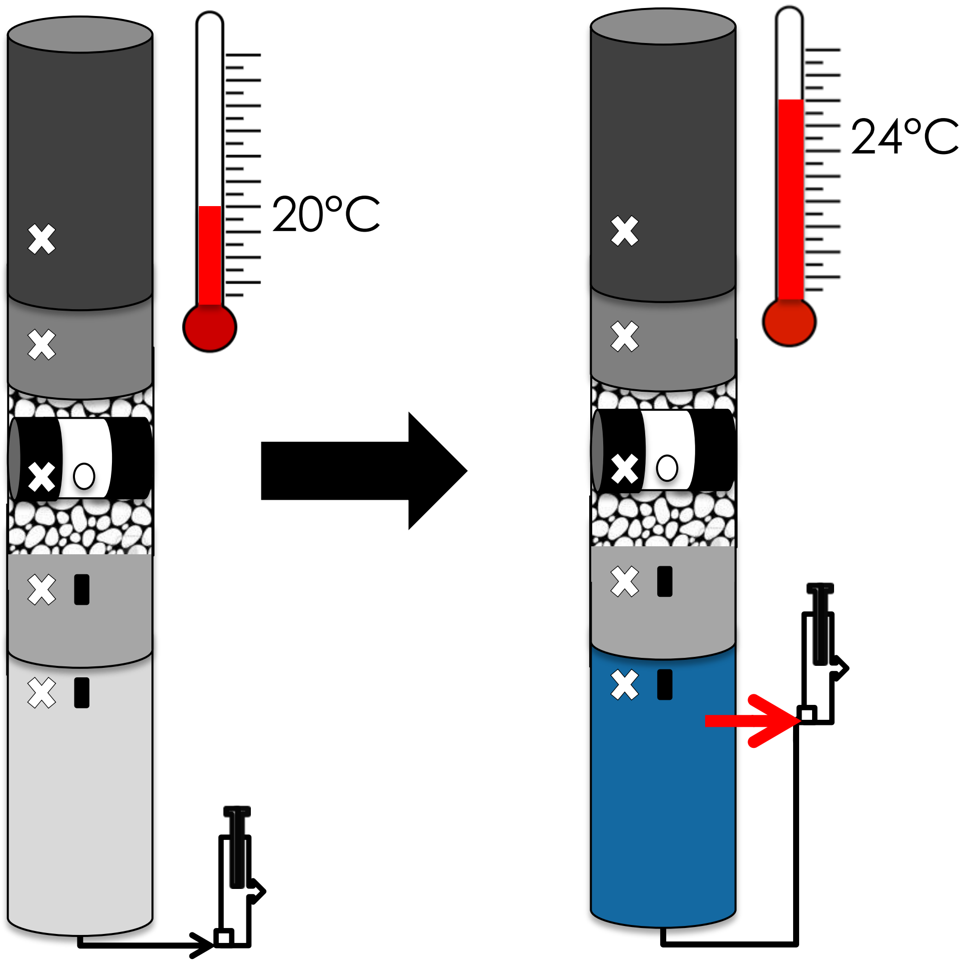
Advanced:

- Pre-treated sand filter effluent (SFE)
- Shallow placement of infiltrative area
- Timed dosing controls
- Less reliance on soil

Conventional:

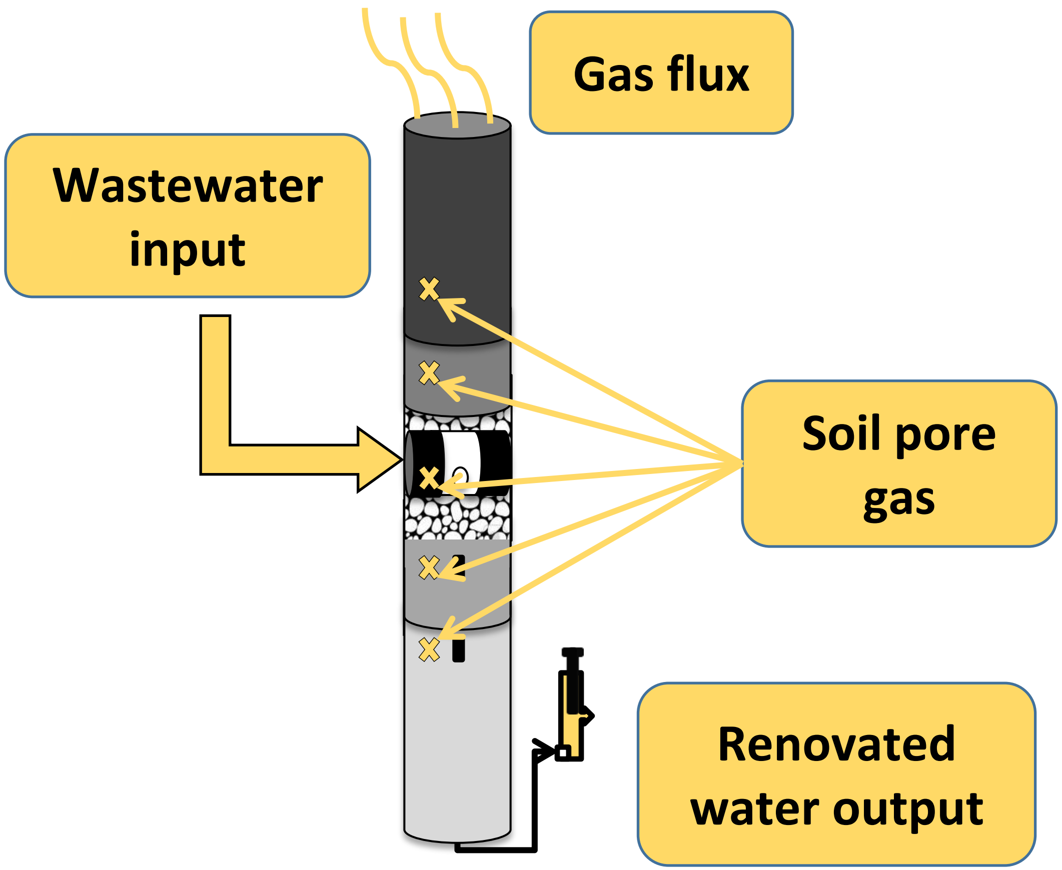
- Septic tank effluent (STE)
- Deeper placement of infiltrative area
- “Social” dosing
- Relies heavily on soil

Testing the Hypotheses: Climate Change



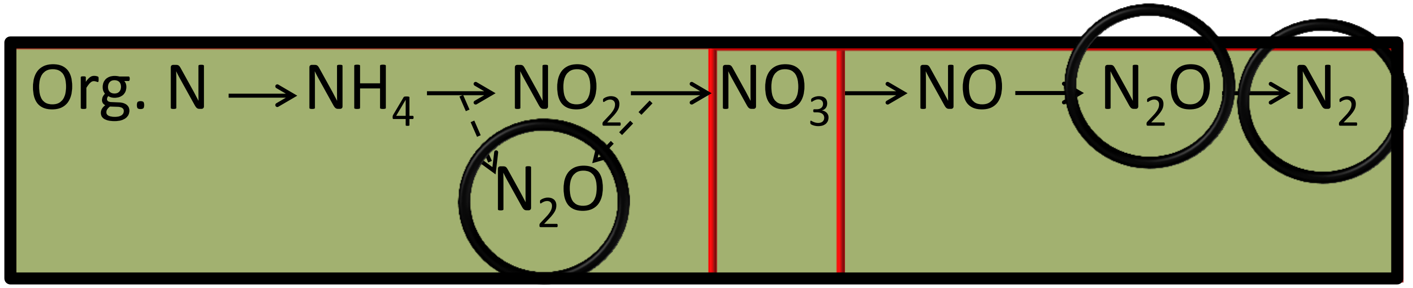
- Current conditions
  - 20°C
  - Water table within technology specifications
- Climate change scenario
  - Temp. increase to 24°C
  - Water table elevated 30 cm

Testing the Hypotheses: Differences Among Technologies



- Contaminants of concern
  - BOD
  - Fecal coliform bacteria
  - MS2 bacteriophage
  - Total nitrogen
  - Total phosphorus
- Supporting analytes
  - Mechanistic determinations
- Climate change?
  - Advanced technologies more resilient
  - Conventional system release fecal coliform and P

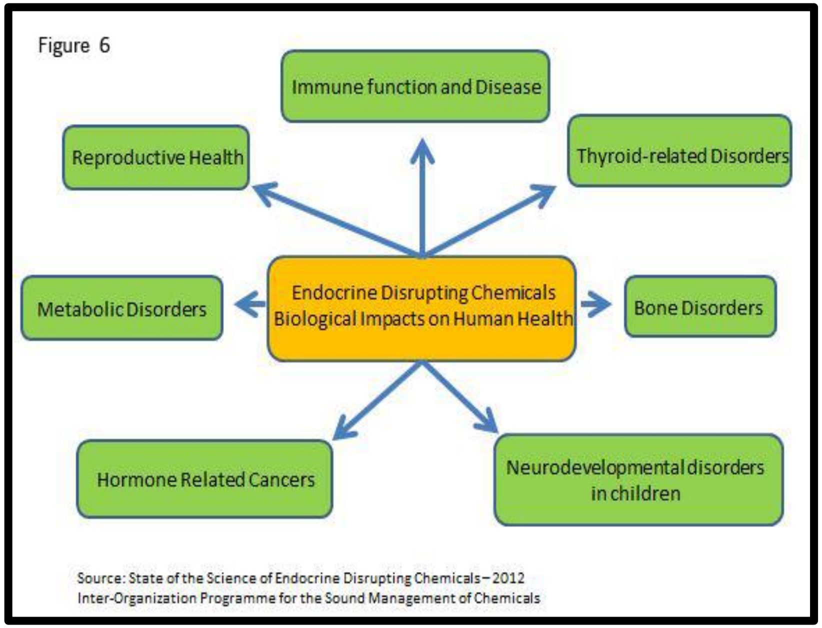
Testing the Hypotheses: Mechanisms of N Removal



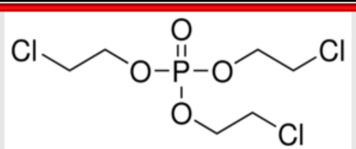
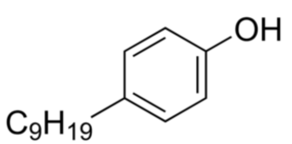
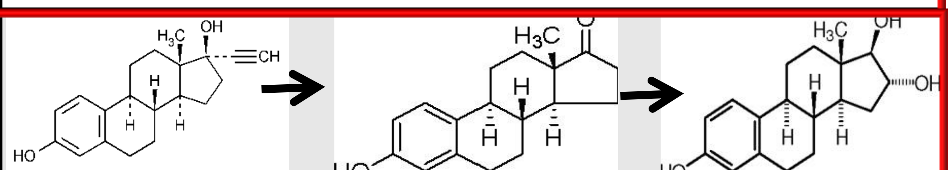
Mineralization/nitrification	Denitrification
Aerobic	Anaerobic

- Eutrophication from N release
- N loss as N_2O and N_2
- Measure dissolved and gaseous N constituents
- Use ^{15}N tracer to elucidate mechanisms
- Climate change?
    - Enhance denitrification and loss as N_2.

Testing the Hypotheses: Removal of Estrogenic PPCPs



- Limited studies of OWTS PPCP removal
- Potent at low concentrations
- Climate change?
  - Less available O_2
  - Release of estrogenic PPCPs

Compound	Use	Conc.	Structure
Tris-(2-chloroethyl) phosphate (TCEP)	Fire Retardant	ng-µg/L	
Nonylphenol	Manufacturing additive	ng/L	
17α-ethynylestradiol (estrone & estradiol)	Synthetic estrogen and deg. prods.	ng/L	

ABQ365 EVENTS

POWERED BY ALBUQUERQUE CONVENTION & VISITORS BUREAU

Featured Events Spotlight

Gathering of Nations Pow Wow

April 24-26, 2014

Related Events

16th Annual Santeros ...

Event Details

Through December 31, 2014
Time: 9:00 AM to 5:00 PM
Recurrence: Every Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday
Admission: $7 adults, $6 seniors, $4 kids, under 3 free

Location:
New Mexico Museum of Natural History & Science

1801 Mountain Rd. N.W.,
Albuquerque, NM 87104
Phone: 505-841-2800

http://www.nmnaturalhistory.org

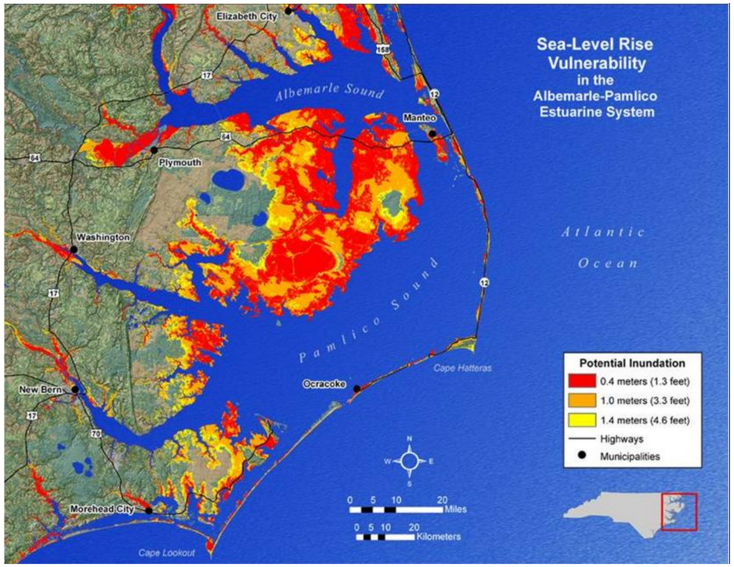
Exhibition: Degrees of Change-New Mexico's Climate Forecast

+ Trip Planner

With a focus on New Mexico and the Southwest, this exhibit will reveal current and predicted impacts of climate change on humans, landscapes, and ecosystems, as well as take you back in time to discover the past climates of New Mexico and around the world.

Map View What's Nearby

What do we do?



Inactive, reactive and proactive measures

Climate variability and change → new set of challenges and opportunities

First mentioned at NOWRA conference, April 2012

Embrace:

- Will position our industry to compete and pace well with other entities and disciplines.
- Many others already have climate change planning and management in their future endeavors.

Climate variability and change → new set of challenges and opportunities

Ignore/Deny: Lose hard-earned ground and credibility as an industry.

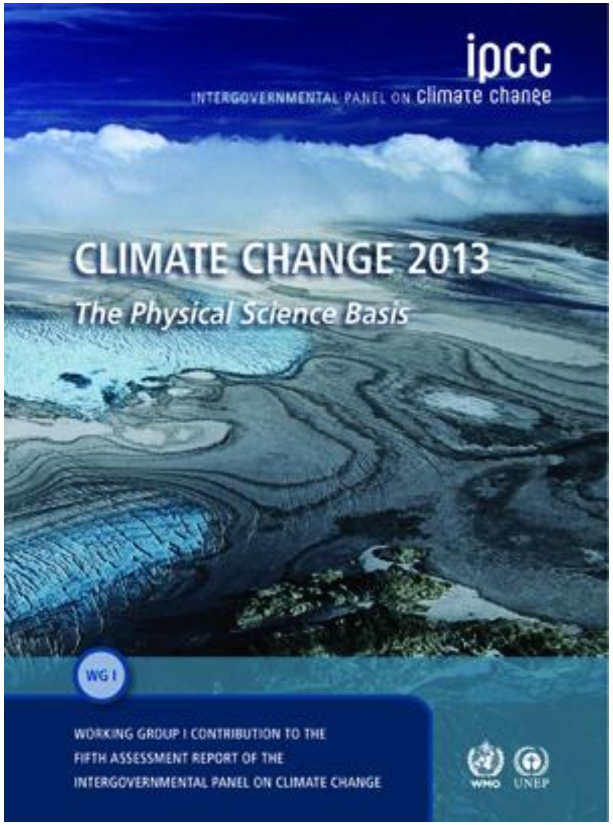
We miss a significant opportunity -
Stressors to effective soil-based wastewater treatment are likely to multiply –

- More importance placed on advance wastewater treatment prior to dispersal
- Affect larger land areas
- If we have answers, we're part of the solution

Adaptation and mitigation

Decentralized wastewater industry –

- Read the science
- Educate yourself, company, agency, and clientele
- Climate change is real, and here to stay
- Proactively address issue(s)
- Stay ahead or loose ground



Adaptation and mitigation

Think integrated water management:

- Manage both stormwater and wastewater
- Use low impact development (LID) measures
- Use green vs gray infrastructure practices
- Increase wetland setbacks and buffers

Engineered swales, bioretention basins and porous pavers

Adaptation and mitigation

Integrated water management:

- Protect areas that collect and infiltrate stormwater
- Minimize limits of disturbance (maintain natural hydrology)
- Decompact soil – restore to original soil hydrologic group

Adaptation and mitigation

Engineering aspects –

- Increase horizontal setbacks:
  - ✓ Units w/small footprint
  - ✓ Indoor treatment units
  - ✓ Waterproof units

- Increase vertical separation and pathogen reduction:
  - ✓ Shallow soil placement
  - ✓ Silver nanoparticles

Adaptation and mitigation

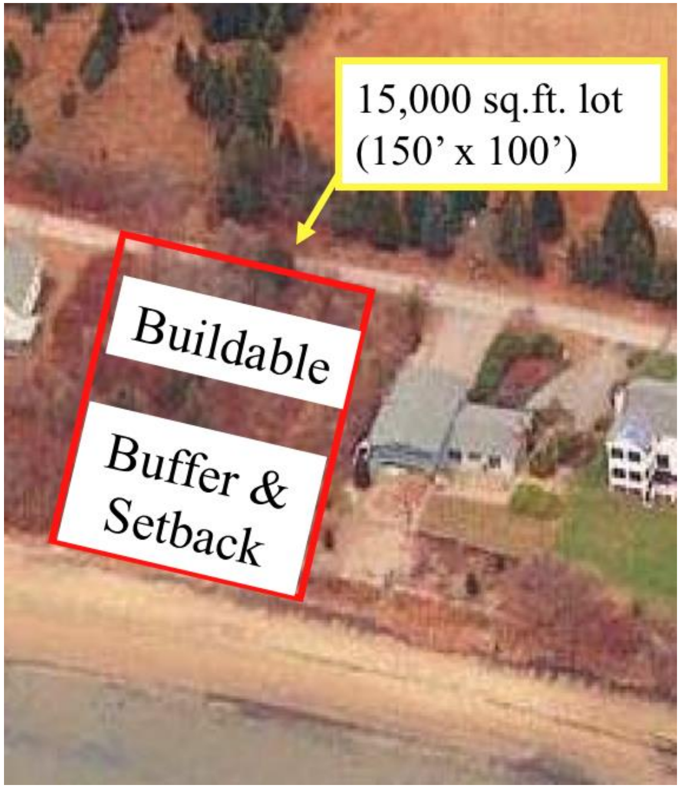
Engineering aspects –

- Nutrient reduction (P, N):
  - ✓ Shallow soil treatment (P)
  - ✓ Improved nutrient reduction systems (>50%)
  - ✓ Urine diversion toilets (source of new industry)

Adaptation and mitigation

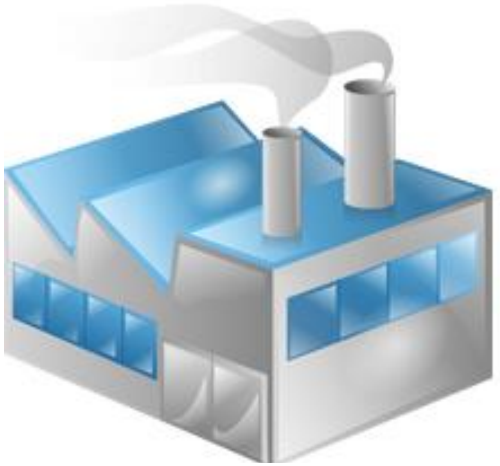
Engineering/regulatory aspects –

- Improved siting criteria:
  - ✓ Increase buffer and setbacks from coastal features



Adaptation and mitigation

Manufacturers –



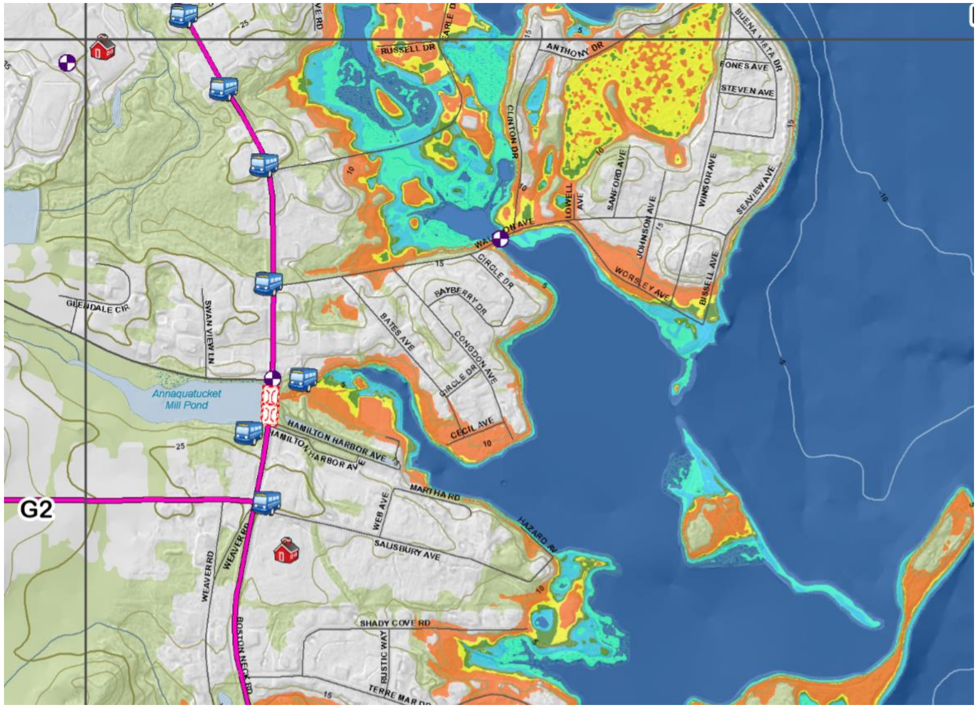
- Adapt existing technologies
- Improve component-based treatment efficiency

- Develop new technologies
- Incorporate moisture management into treatment trains (i.e. flow equalization, timed-dosing)

Adaptation and mitigation

Regulators –

- Map at-risk areas – set priorities
- Develop risk-based policy and regs
- Require accountability for treatment and O&M performance



Facilities and Infrastructure
Sea Level Rise Vulnerability Analysis
North Kingstown, RI

For areas projected to be wetter –

Manage soil moisture

- Promote timed-dosing and flow equalization

Promote shallow wastewater dispersal

- More biochemically reactive soil
- Maximize vertical separation distance
- Maximize retention times

For projected dryer areas -

- Soil treatment area dispersal?
- **Landscape irrigation**
- **Wastewater recycling and reuse**

➢ Component-based wastewater treatment will become even more important

E.g. - Mitigating in humid east coast acute storm impact zones

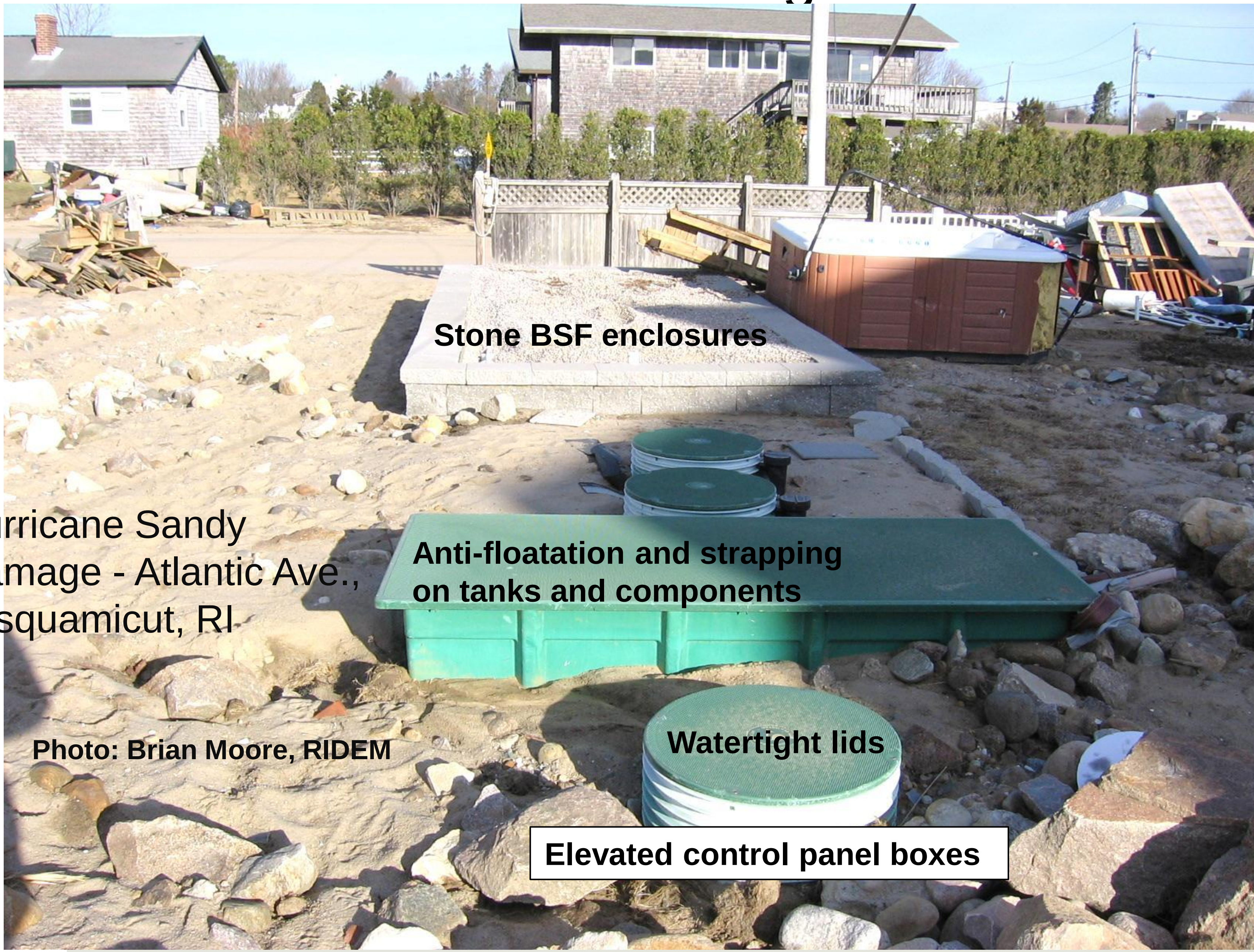
Rhode Island high risk flood and erosion areas

- Repair OWT systems - holding tanks, if 50 ft. to eroded feature; denitrification technologies

Greenhill, RI
(post Hur. Sandy Oct. 2012)

Matunuck, RI

Use risk-based BMPs in designs -



Hurricane Sandy
Damage - Atlantic Ave.,
Misquamicut, RI

Photo: Brian Moore, RIDEM

Educators

USDA – NIFA NE-1045 Hatch Multi-state Project

NERA

HOMEPAGE
OUTLINE
APPENDIX E : PARTICIPATION
HISTORY
SAES-422 (REPORT & MINUTES)
MEETING INFO
PARTICIPANTS DIRECTORY
TECH COMMITTEE OFFICERS
PUBLICATIONS
PHOTO ALBUM
LINKS
ADDITIONAL DOCUMENTS

NE1045: Design, Assessment, and Management of Onsite Wastewater Treatment Systems: Addressing the Challenges of Climate Change

- Opportunity for scientists to address unknowns about OWTS function relative to changing climate.
- 16 scientists from 13 institutions currently engaged
- Cornell, Michigan State, North Carolina State, Oklahoma State, Rutgers, U. Arizona, U. Georgia, U. Kentucky, U. Minnesota, U. Missouri, U. Rhode Island, U. Tennessee.
- Enabled the start of several important research efforts
- Begun the task of informing the industry and practitioners of this important issue.
- **New educational institution members are welcome!**

NE 1045 Objectives summary:

1. OWTS and soil hydraulic transport parameters.

2. New OWTS design criteria and climate change adaptation and mitigation.

3. Soils, geomorphology, topography, and climate conditions.

4. Outreach education on OWTS and climate change.

NE 1045 Objectives summary:

1. Group meets for 1-day annual meeting.

2. Meeting coordinated with SSSA annual meeting.

3. Next meeting is on November 2, 2014 in Long Beach, CA.

4. SSSA Onsite Wastewater Conference on April 7-8, 2014 a direct product of NE1045.

Acknowledgements:

- USDA NIFA NE-1045 Multi-state Hatch Project
- Rhode Island Agricultural Experiment Station
- Rhode Island Cooperative Extension
- State of Rhode Island and Providence Plantations
- Rhode Island Sea Grant Program